PB88-118492

Evaluation of Emission Factors for Formaldehyde from Certain Wood Processing Operations

Radian Corp., Research Triangle Park, NC

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

Oct 87

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-450/3-87/023		PB88 118492/AS

4. TITLE AND SUBTITLE	5. REPORT DATE
Evaluation of Emission Factors for Formaldehyde from Certain Wood Processing Operations	October 1987
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Air Quality Planning and Standards U.S. Environmental Protection Agency (EPA) Research Triangle Park, North Carolina 27711	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS DAA for Air Quality Planning and Standards Office of Air and Radiation U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711	13. TYPE OF REPORT AND PERIOD COVERED Final 14. SPONSORING AGENCY CODE EPA/200/04

15. SUPPLEMENTARY NOTES

16. ABSTRACT

A State pollution control agency requested assistance from EPA's Control Technology Center (CTC) in estimating formaldehyde emissions from furniture manufacturing processes. These plants use urea-formaldehyde adhesive resin formulations which emit formaldehyde during application, curing, and storage.

The primary sources of information for this study include library and permit data base searches, telephone conferences and meetings with members of the furniture and adhesive manufacturing industries.

The report estimates emission factors for the most significant sources and discusses the impact of process variables and modifications on these emissions.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Pollution Control Volatile Organic Compounds Air Toxics Formaldehyde Wood Processing Furniture Manufacture	Air Pollution Control Stationary Sources	13B

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Unlimited	UNCLASSIFIED	79
	20. SECURITY CLASS *(This page)*	22. PRICE
	UNCLASSIFIED	PC14.95/MF 6.95

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

PB88-118492

United States
Environmental Protection
Agency

Control Technology
Center
Research Triangle Park NC 27711

EPA-450/3-87-023
October 1987

EPA

Evaluation of Emission Factors for Formaldehyde from Certain Wood Processing Operations

control technology center

CTC

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U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA. 22161

EPA-450/3-87-023

EVALUATION OF EMISSION FACTORS FOR FORMALDEHYDE FROM CERTAIN WOOD PROCESSING OPERATIONS

CONTROL TECHNOLOGY CENTER

SPONSORED BY:

Emission Standards and Engineering Division
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Air and Energy Engineering Research Laboratory
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U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Center for Environmental Research Information
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268

October 1987

NOTICE

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ACKNOWLEDGEMENT

This report was prepared for the Control Technology Center by C.E. Burklin and T.S. White of Radian Corporation. The EPA project officer was Leslie B. Evans of the Office of Air Quality Planning and Standards. Also serving on the EPA project team was Bruce Tichenor of the Air and Energy Engineering Research Laboratory.

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1.0 INTRODUCTION

1.1 SCOPE

The Control Technology Center (CTC) was established by the Environmental Protection Agency's (EPA) Office of Research and Development and the Office of Air Quality Planning and Standards to assist State and local air pollution control agencies in the implementation of their air toxics and other pollution control programs. Three levels of assistance can be accessed through the CTC. First, a CTC HOTLINE has been established to provide telephone assistance on matters relating to air pollution control technology. Second, more in-depth engineering assistance can be provided when appropriate. Third, the CTC can provide technical guidance through publication of technical guidance documents, development of personal computer software, and presentation of workshops on control technology matters.

This report presents the results of direct engineering assistance provided by the CTC for the State of Virginia. The scope of the assistance was determined by the specific needs of the State, and the findings presented in this report may not be applicable to other facilities and operations which were not evaluated. Also, control technology presented in this report is not necessarily endorsed by EPA for establishment of the basis for regulations, since the decision of whether or not to regulate a source category and the selection of the technology on which to base regulations are responsibilities of the individual State or local authorities. This report is, however, intended to provide technical information which may assist in making such decisions.

The scope of this report is to present to the State of Virginia a survey of the sources which contribute to formaldehyde emissions in the furniture manufcturing process and to estimate formaldehyde emissions from the most significant sources. The report discusses the impact of process variables and modifications on these emissions. The primary sources

of information for this study include library and permit data base searches, telephone conferences, and meetings with members of the furniture and adhesive manufacturing industries.

1.1 BACKGROUND

The Virginia State Air Pollution Control Board (VSAPCB) regulates formaldehyde emissions from furniture plants under its Air Toxics Rules. Manufacturers subject to the rules are required to report the estimated formaldehyde concentration at their plant fencelines after applying an appropriate dispersion model to plant sources.

Furniture manufacturers use urea-formaldehyde (U-F) adhesive resin formulations which contain formaldehyde in excess of the amount required to form the urea-formaldehyde polymer. As an alternative to fenceline testing, VSAPCB currently allows a furniture plant to assume that 100 percent of the excess formaldehyde in its adhesive formulation is emitted from plant vents. This number becomes an input parameter to the dispersion model that the plant uses to estimate fenceline concentration.

To refine its emission assumption of 100 percent excess formaldehyde loss, VSAPCB requested technical assistance from U. S. EPA's Control Technology Center, an intra-agency group. In response to the VSAPCB request, the Control Technology Center contracted Radian to research published formaldehyde emission data and, if possible, to refine the emission estimate for the furniture manufacturing industry.

1.2 FINDINGS

Industry contacts provided the details of the manufacturing process and revealed the level of technology applied by furniture manufacturing plants to reduce emissions. They also revealed the general procedures used in manufcturing and testing U-F adhesive resins. Discussions at the "Formaldehyde Reporting and Control" workshop in Richmond, Virginia, revealed the actual ranges of temperature, pressure, and resin application rate used during furniture and particleboard press operations. The industry also revealed many of the problems involved with process modifications as an emission control technique.

No furniture plant emission data were found. Therefore, related industries were researched, including the particleboard manufacturing industry.

From the standpoint of emission mechanism, the particleboard industry was found to use similar U-F adhesive resins. Three significant sources of process emissions data from this industry were found, including data from the paper industry's National Council for Air and Stream Improvement, Inc. (NCASI),[1] the work of Tomas,[2] and the results of a German U-F particleboard plant survey.[3]

1.3 CONCLUSIONS

1. From 1.9 to 12 percent of the excess formaldehyde in the resin is emitted to the atmosphere during particleboard manufacture, with an average emission rate of 4.7 percent.[1]

2. In furniture plants a smaller percentage of the excess formaldehyde is likely to be emitted than in particleboard plants because of less severe press conditions and a different product configuration.

3. Comprehensive plant testing will be required to determine exactly formaldehyde emissions from furniture plants.

4. The titration procedure which is often used to determine the excess formaldehyde in a particular adhesive resin has not been standardized by the industry. It has been found that resin temperature, titration time and resin pH can all have a significant effect on the results of the procedure. A standard bisulfite titration procedure should be adopted industry-wide before excess formladehyde content can be accurately estimated by the titration technique.

5. Process modifications have a significant impact on the formaldehyde emission rate and promise to be a very effective way to achieve a 50-75 percent reduction. However, the implementation of process modifications will require a significant research and development effort, since process modifications must be accompanied by other compensating process changes and possibly equipment changes.

1.4 REPORT ORGANIZATION

This report is organized in the following way: Section 1.0 is the Introduction, Section 2.0 is the Process Description, Section 3.0 presents Emission Characteristics, and Section 4.0 contains References.

2.0 PROCESS DESCRIPTION

The major processing steps in both particleboard and furniture manufacturing processes which use urea-formaldehyde adhesive resins are outlined in this chapter. Section 2.1 describes Furniture Manufacturing and Section 2.2 describes Particleboard Manufacturing. The Chemistry of U-F Resins is discussed in Section 2.3, and Section 2.4 presents Formaldehyde Content Measurement Techniques.

2.1 FURNITURE MANUFACTURING

The products from this industry include furniture made from particleboard and plywood with one or two layers of veneer glued on each side. The glue, a urea-formaldehyde adhesive, is usually applied to the veneer and board surface to a thickness of 0.03 inches. This adhesive is applied with a series of rollers that convey the adhesive from a "glue pot" where the adhesive is continuously mixed to the veneer and board surface. Immediately after adhesive is applied, the veneer is placed on the particleboard or plywood. The pieces are then pressed between the surfaces of a heated press, typically ranging from 250 to 300^{o}F. The length of time in the press depends on the number of layers being glued, but ranges from 45 seconds for a single veneer layer up to six minutes for five layers. Press pressures range from 100 to 175 psi. Twenty-five to 50 pounds of adhesive are used per ply per thousand square feet (MSF) of board. The ranges of press operating conditions for the furniture industry are summarized in Table 2-1.

Urea-formaldehyde formulations include some excess formaldehyde (unpolymerized) to improve adhesion characteristics. Common formulations range from less than one to over six percent excess formaldehyde by weight of water free U-F resin. (This method of defining U:F formulations is discussed in Section 2.4, Formaldehyde Content Determination Techniques.) Adhesive manufacturers have been working with the furniture manufacturers to develop adhesives that are low in excess formaldehyde. As a result, the excess formaldehyde concentration in formulations has been dropping.

Some furniture manufacturers add a catalyst to their adhesive formulations prior to application to lower the pH. The lower pH combined

TABLE 2-1. COMPARISON OF PRESS OPERATING CONDITIONS FOR FURNITURE AND PARTICLEBOARD MANUFACTURING INDUSTRIES

Operating Condition	Product Category	
	Furniture	Particleboard
Press Temperature (^{o}F)	250 - 300	315 - 385
Press Pressure (psi)	100 - 175	150 - 800
Press Cycle Time (min)	0.75 - 6	4 - 9
LB Resin/MSF (3/4")	25 - 50*	150 - 290
Excess Formaldehyde (weight % of dry resin)	<1 - 6	<1 - 8

*Per glue line

with heat from the press causes the adhesive to cure faster. Catalysts are slightly acidic mineral salts such as ammonium chloride.

Some plants use a hood over the press to pull formaldehyde emissions out of the workplace and release them via a roof vent or stack. One plant in New York reportedly burns some press fumes in its gas-fired dryer.[4]

2.2 PARTICLEBOARD MANUFACTURING

Particleboards are board products composed of distinct particles of wood or other ligno-cellulosic materials bonded together with an organic binder. Particleboard often serves as a base onto which veneer layers are glued in furniture manufacture. The thickness of each product varies, typically ranging from 0.5 to 1.5 inches.

To manufacture particleboard, wood particles are blended with a urea-formaldehyde adhesive resin and a small amount of wax. The wax is added to promote binding of the resin to the wood particles. Formers spread the mixture of wood particles and U-F resin onto platens to form mats. The mats are pressed at 150 to 800 psi in a heated press at 315 to 385^{o}F for a time period appropriate for the thickness, density and grade of the product (four to nine minutes).

The urea-formaldehyde resin as applied is partially polymerized with approximately 65 percent solids. The remaining compound is water. For some products such as door core, a resin high in excess formaldehyde (high-fuming resin) is used to reduce the press cycle time. The excess formaldehyde content of the U-F resin used to produce commercial grade particleboard ranges from less than one percent up to eight percent by weight of the dry resin.

The NCASI survey of particleboard press vents did not describe ventilation specifically, but it reported formaldehyde mass emission rates from the press and cooler vents. One of the authors indicated that emissions are pulled away from the presses by mechanical draft roof vents.

2.3 CHEMISTRY OF U-F RESINS

Urea and formaldehyde are partially reacted by the resin supplier to form the U-F adhesive resin. At this stage, this resin is predominately a linear

polymer of alternating urea and formaldehyde monomers with some cross-linking. Formaldehyde is added in excess of that required by stoichiometry to react with the urea. This excess formaldehyde is required later to drive the cross-linking reaction to completion. Final cross-linking occurs in the adhesive as furniture pieces are joined in a heated press. This process is called curing.

The formaldehyde and urea are initially combined by the resin supplier under acidic conditions. After the appropriate degree of polymerization is obtained, the reaction is arrested by raising the mixture pH. Sometimes, urea or other chemicals are added at the end of the reaction to tie up a portion of the excess formaldehyde present and reduce press operation emissions. The adhesive resin is sold in this form.

A furniture manufacturer will typically lower the pH prior to use by adding a weakly acidic reagent in water (e.g., ammonium chloride). This mixture is spread on a ply and put in a press where the combination of acidic conditions and heat from pressing quickly completes the cross-linking reaction. The cross-linking reaction forms a solid space-network polymer and causes adhesion between plies.

2.4 FORMALDEHYDE CONTENT DETERMINATION TECHNIQUES

For the purposes of the report, "excess" formaldehyde is defined as the weight percent of formaldehyde based on total dry resin solids in excess of the amount of formaldehyde required to react stoichiometrically with the urea in the resin. Excess formaldehyde is often calculated from the mole ratio of F:U supplied by the resin manufacturer. Therefore, an adhesive resin having a F:U molar ratio of 1.03:1 (1:03 moles of formaldehyde to 1 mole of urea) will contain one weight percent "excess" formaldehyde.[1] In this paper, one weight percent excess formaldehyde based on dry resin weight and calculated from the formulation will be expressed as 1 weight % (dry resin; f).

The level of excess formaldehyde can also be measured using titration techniques. A bisulfite titration method for analyzing excess formaldehyde as a weight percent of adhesive resin solids is generally used as quality control indicator of the final resin. The accuracy of the titration depends strongly on temperature, titration time, and resin pH. Different resin manufacturers

use slightly different titration procedures. Some of the testing techniques that have been developed are proprietary in nature. A procedure developed by Borden Chemical is reportedly accurate to within 0.1 percent of the excess formaldehyde present at an excess formaldehyde level of 0.5 weight percent (dry resin basis).[5] Another source reports a tenfold increase in weight percent excess formaldehyde when the procedure is run at 25°C vs. 0°C for the same resin.[6] Normally, the titration procedure is performed at 25°C, where the adhesive industry generally considers the results most accurate.

The difference between test methods must be addressed and the methods standardized before an emission estimate can be based upon titratable formaldehyde in the adhesive resin a plant uses.

In this paper, one weight percent excess formaldehyde based on dry resin weight and measured by titration will be expressed as 1 wt% (dry resin; t).

3.0 EMISSION CHARACTERISTICS

3.1 SOURCES OF EMISSIONS IN FURNITURE MANUFACTURING

The sources of formaldehyde emissions in the manufacture of furniture are described in this section. An overview of general plant formaldehyde sources is given in Section 3.1.1, while the major source, the press, is discussed in Section 3.1.2.

3.1.1 Overview

The catalyst/resin blending operation and glue pot are small contributors to total plant formaldehyde emissions. When the adhesive is spread over large veneer or particleboard areas, the air exposure time is typically one to two minutes and formaldehyde emissions can be significant. These emissions are exhausted by fans through windows and roof vents. Other process steps which can be significant sources include the board cooling area, the finishing room, and conveyor emissions. Here, formaldehyde diffuses through the veneer layers themselves and is emitted from the edges of finished stock. Alkyd-urea synthetic varnish blends used in finishing can be a formaldehyde source, as can the wood drying process. Exhaust fans provide ventilation in these areas through windows and roof vents.

Other minor sources include long-term board degassing during warehousing of finished products and emissions from particleboard used as a raw material in the process. Storage is a small contributor to total plant emissions because air exchange rates in warehouses are typically low. During storage, formaldehyde is exhausted to the atmosphere through warehouse doors, windows and roof vents.

3.1.2 Press

During the press cycle, boards are compressed at temperatures of 250^{o} to 300^{o}F. Water vapor and formaldehyde gases are generated from the adhesive, and are emitted through the veneer surface and board edges throughout the pressing cycle. Emissions are typically exhausted through roof vents by large fans when the press is opened for unloading and loading.

The press area is the largest contributor to total plant formaldehyde emissions. In one particleboard plant, 95 percent of total plant formaldehyde emissions came from vents over the press, unloader and associated conveyors.

3.2 PRESS EMISSION ESTIMATE

No published formaldehyde emission data were available for furniture manufacturing operations. However, emissions data from particleboard plants have been published. Similarities and differences between the particleboard and furniture pressing processes include 1) the adhesive surface is more exposed in particleboard during and after pressing, 2) both industries are now optimizing on low-emitting U-F resins, 3) particleboard presses operate at higher temperatures and pressures, and 4) particleboard presses have longer cycle times. In general, particleboard plant operations and conditions are more conducive to formaldehyde evaporation than are furniture plant operations.

Section 3.2.1 discusses formaldehyde emissions from particleboard and Section 3.2.2 relates these formaldehyde emissions to furniture manufacture.

3.2.1 Particleboard Manufacturing Emissions

NCASI found average particleboard emissions of 0.5I lbs formaldehyde per thousand square feet (MSF) on a 3/4" basis with a range of 0.22 to 0.84. These emissions when expressed as a percent of the excess formaldehyde in the adhesive resin averaged 4.7 percent with a range of 1.9 to 12.0 percent. Table 3-1 contains a summary of formaldehyde emissions from the four plants surveyed by NCASI. In these plants, the excess formaldehyde content of the adhesive ranged from three to eight weight percent (dry resin; f) the amount of adhesive used averaged from five to nine percent of total board weight, and press temperature ranged from 315^{0} to 385^{0}F.

A recent study of German particleboard plants found an average formaldehyde emission rate of 0.39 lb/MSF (3/4" basis). These findings agree favorably with those of the above NCASI study.

The processing parameters which have been found to impact formaldehyde emission rates are 1) excess formaldehyde in the adhesive, 2) press temperature, 3) press cycle time, 4) the amount of adhesive used, and 5) the use of formaldehyde scavengers. Each is discussed below.

3.2.1.1 Excess Formaldehyde in the Adhesive. Excess formaldehyde is thought to be the primary source of emissions from adhesive curing. It affects the amount of formaldehyde available for evaporation. In recent years, the particleboard industry has responded to public concern about formaldehyde emissions in indoor environments by manufacturing their boards

TABLE 3-1. FORMALDEHYDE EMISSIONS FROM FOUR PARTICLEBOARD PLANTS

Parameter	Average*	Range
Emitted Formaldehyde		
LB/MSF (3/4")	0.51	0.22 - 0.84
As % of Excess HCHO in the Resin	4.7	1.9 - 12
Conditions		
Press Temperature (^{o}F)	339	315 - 385
LB Resin/MSF (3/4")	216	150 - 290
Excess HCHO in Resin (wt% [resin; f])	5.9	3.2 - 7.7

*Average of all data points from the four plants tested.

to conform to tighter off-gassing specifications. Particleboard presses are operated so that more of the excess formaldehyde present in the board is liberated during pressing and less is emitted later, in indoor environments. In addition, adhesive resin suppliers have worked to reformulate particleboard resins which emit at much lower rates after curing (some of the adhesives now supplied to furniture manufacturers also emit at lower rates than the adhesives supplied in the past).

Data from Tomas suggests that reducing excess formaldehyde from five weight % (dry resin; t) to one weight % (dry resin; t) reduces formaldehyde emissions from particleboard curing by 55 percent. Figure 3-1 presents data from the NCASI Survey on formaldehyde emissions as a function of the excess formaldehyde in the board expressed as a percent of board weight, and shows the same general relationship. Some adhesive formulations have excess formaldehyde levels below one weight % (dry resin; t). Catalyst additions and/or press condition adjustments must be made to compensate if excess formaldehyde is reduced in any given adhesive.

3.2.1.2 Press Temperature. High press temperatures cause the volatilization of excess formaldehyde and possibly the destruction of other organic compounds to form formaldehyde. Tomas indicates that a reduction in the particleboard press temperature from 338^{o}F down to 284^{o}F reduced formaldehyde emissions by 42 percent. This is illustrated in Figure 3-2. Reduced press temperatures require either increased curing times or more active catalysts. Temperatures reported by the furniture industry range from 250 to 300^{o}F. One source reports that some adhesives can be "cold-cured" at room temperature, but curing time is increased by two to three orders of magnitude over hot pressing times.

3.2.1.3 Press Cycle Time. Formaldehyde emissions are thought to be dependent on the length of time the adhesive is exposed to high press temperatures. The NCASI survey of particleboard plants did not see this phenomenon in formaldehyde data. However, the trend was noted in total gaseous non-methane organics (TGNMO) data. Figure 3-3 shows that reducing the press cycle time from 8.5 minutes to 5 minutes reduced TGNMO emissions by 73 percent.

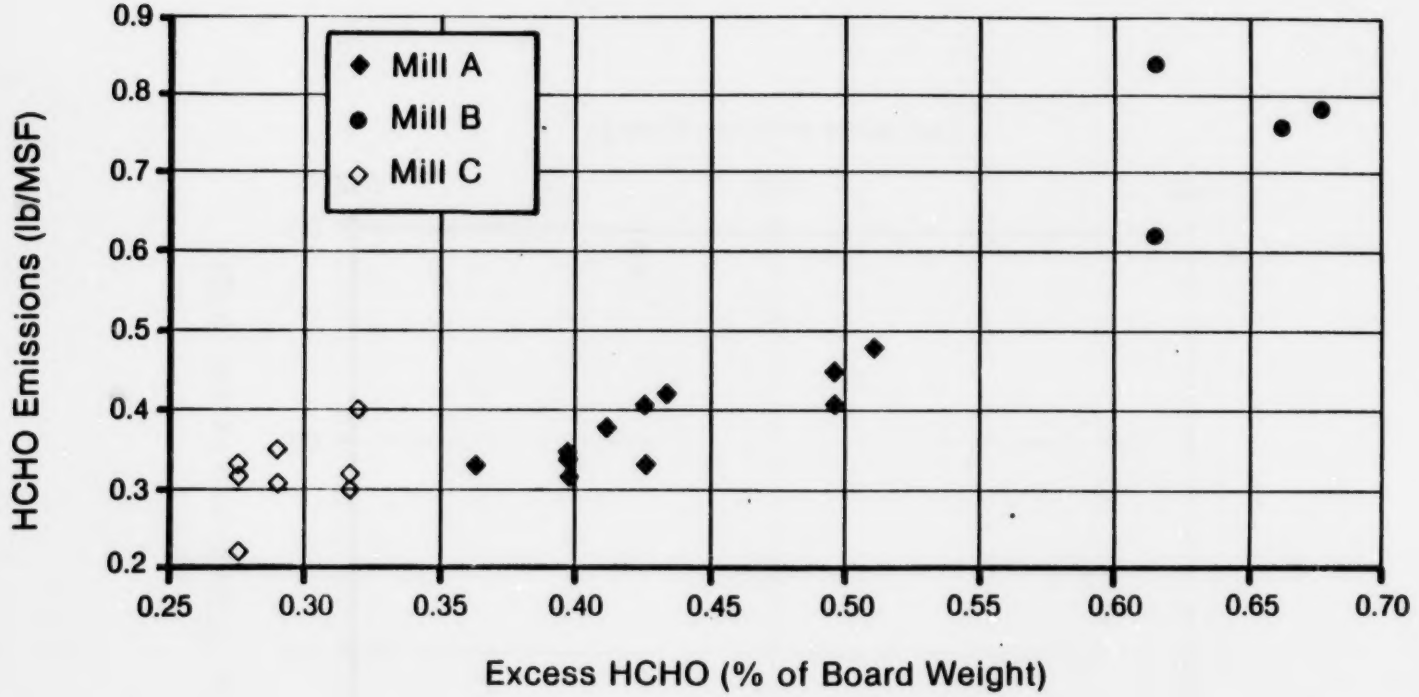

Figure 3-1. Impact of Excess Formaldehyde on Emissions from Particleboard Presses

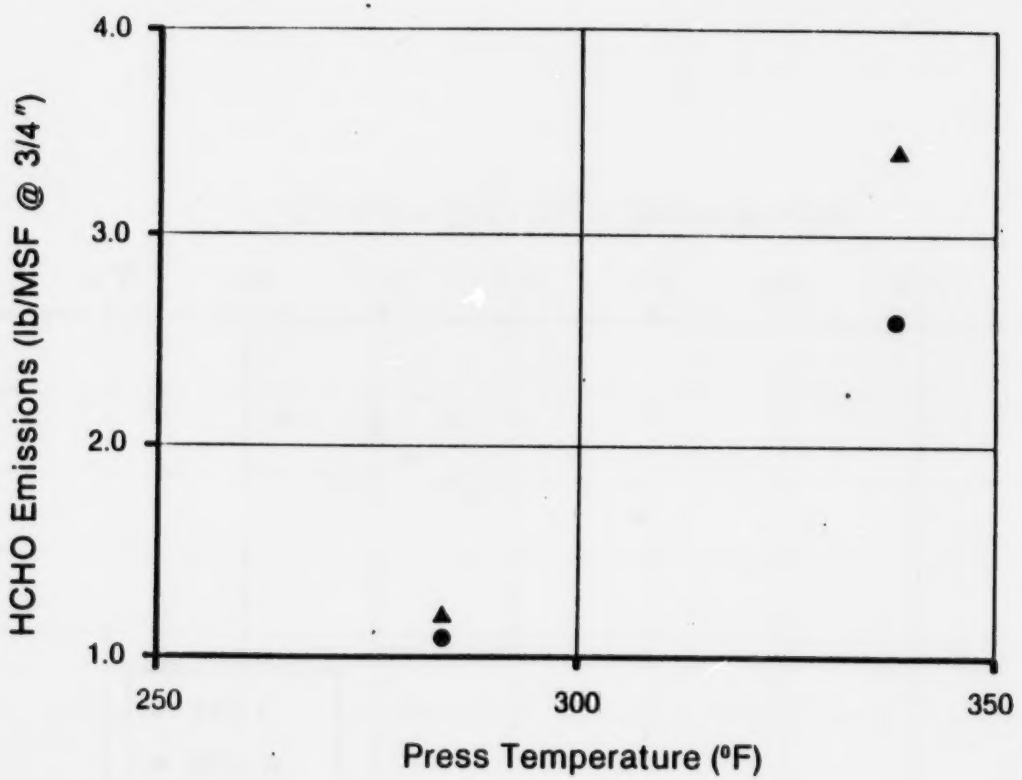

Figure 3-2. Impact of Temperature on Emissions from Particleboard Presses (Pilot-Scale Experiments)

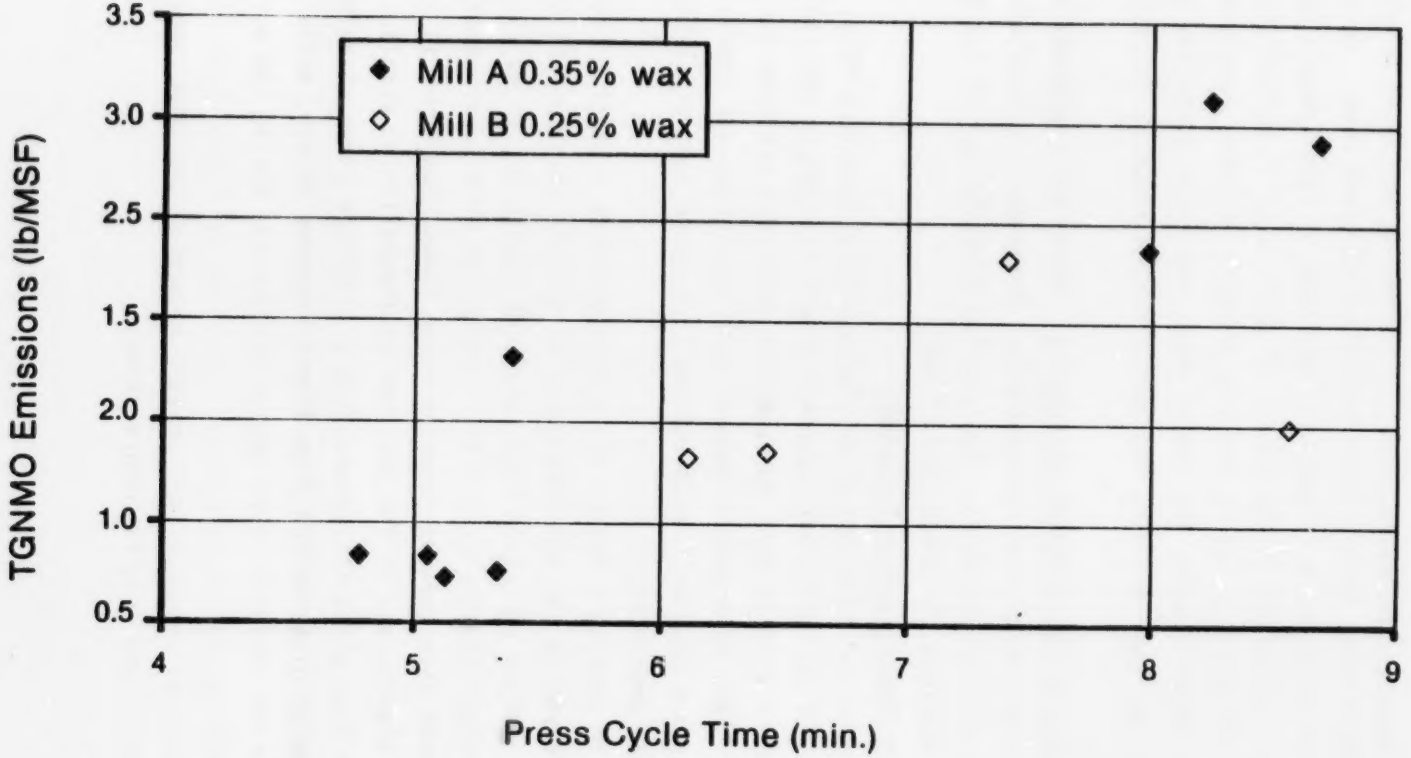

Figure 3-3. Impact of Cycle Time on Emissions from Particleboard Presses

3.2.1.4 Amount of Adhesive Used. Formaldehyde emissions are thought to be directly proportional to the total amount of adhesive used. As shown in Figure 3-4, NCASI observed a 22 percent reduction in formaldehyde emissions for a 21 percent reduction in the amount of resin used in particleboard formulations. If adhesive use is too low, however, bonding strength is inadequate. In recent years, the use of waxes and surfactants has improved bonding properties, thus allowing the particleboard industry to reduce adhesive use.

3.2.1.5 Use of Formaldehyde Scavengers. These are compounds which associate with and tie up free formaldehyde. Scavengers include urea, ammonia compounds, and sulfite compounds. One problem with the use of scavengers is that they can increase the press cycle time.

3.2.2 Furniture Manufacturing Emissions

In the absence of furniture plant formaldehyde emissions data, the available range of particleboard manufacturing formaldehyde emissions data may be used to predict a worst-case formaldehyde emissions estimate for furniture manufacturing. This is possible because both industries use similar U:F adhesive resins and both utilize board pressing operations at elevated temperatures and pressures.

However, in furniture plants it is possible that a smaller percent of the excess formaldehyde in the adhesive resin is emitted than in particleboard plants. Formaldehyde emissions from furniture plants are probably lower because: 1) presses in furniture plants operate at much lower temperatures, 2) furniture presses have somewhat shorter cycle times than those in particleboard plants, and 3) the physical configuration of furniture pieces is different than that of particleboards (in a furniture piece, a veneer barrier protects the major glue surface from direct exposure to air, while no such continuous barrier inhibits formaldehyde evaporation during the particleboard pressing cycle).

Only comprehensive plant testing will determine the true range of formaldehyde emissions from furniture plants.

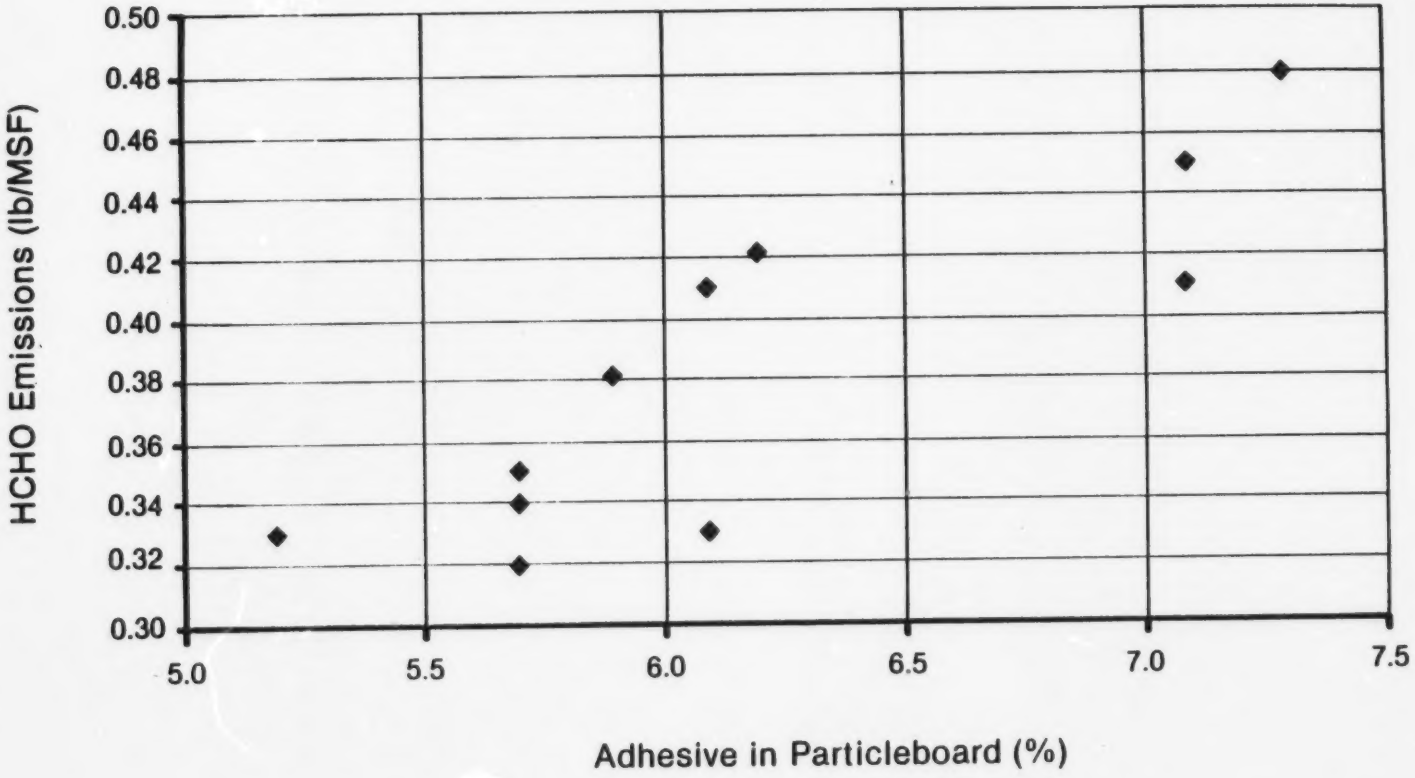

Figure 3-4. Impact of Adhesive Useage on Emissions from Particleboard Presses

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22. Telecon. Wright, Ken, Lane Furniture Company, with Pelland, A. S., Radian Corporation. June 16, 1987.

23. Telecon. Thorton, Meaux, American Furniture, with Pelland, A. S., Radian Corporation. June 16, 1987.

24. Telecon. Newton, Larry, Georgia Pacific, with White, T. S., Radian Corporation. June 17, 1987.

25. Telecon. Parish, Jon, Lane Furniture Company, with Pelland, A. S., Radian Corporation. June 17, 1987.

26. Telecon. Spencer, Don, NYDEC, with Pelland, A. S., Radian Corporation. June 17, 1987.

27. Telecon. Reid, Tim, Masonite Corporation, with White, T. S., Radian Corporation. June 18, 1987.

28. Telecon. Groah, Bill, Hardwood-Plywood Manufacturers Association, with White, T. S., Radian Corporation. June 18, 1987.

29. Telecon. Barrier, Don, Southeastern Adhesives, with Burklin, C. E., Radian Corporation. June 18, 1987.

30. Telecon. Murray, John, Formaldehyde Institute, with Burklin, C. E., Radian Corporation. June 18, 1987.

31. Telecon. Yatts, Lowell, Lane Furniture Company, with Pelland, A.S., Radian Corporation. June 18, 1987.

32. Telecon. Waters, George, Borden Chemical, with White, T. S., Radian Corporation. June 19, 1987.

33. Telecon. Waters, George, Borden Chemical, with White, T. S., Radian Corporation. July 17, 1987.

34. Telecon. Skiest, Jeane, Borden Chemical, with White, T. S., Radian Corporation. July 17, 1987.

35. Telecon. Dallons, Victor, NCASI, with Burklin, C. E., Radian Corporation,. July 21, 1987.

36. Telecon. Newton, Larry, Georgia Pacific Co., with White, T. S., Radian Corporation. July 22, 1987.

APPENDIX A

PARTICLEBOARD EMISSION DATA

TABLE A-1. FORMALDEHYDE EMISSIONS FROM PARTICLEBOARD PRESS VENTS AS MEASURED IN FOUR MILLS *

Mill & Run Identifier	Emission Rate (as % of excess HCHO in resin)	Emission Rate (lb HCHO/MSF @ 3/4 in)	Press Time (Span, min)	Press Temp (F)	Excess HCHO (wt% [resin; f])	% Resin (lb/100 lb board)
A-1	4.0	0.53	4.8 - 8.7	320	6.7	7.3
A-2	2.5	0.41		320	6.7	7.1
A-3	2.7	0.45		320	6.7	7.1
A-4	2.5	0.41		320	6.7	7.1
A-5	5.4	0.61		320	6.7	6.1
A-6	5.3	0.57		320	6.7	5.9
A-7	3.3	0.35		320	6.7	5.7
A-8	4.0	0.38		320	6.7	5.7
A-9	3.4	0.36		320	6.7	5.2
A-10	3.0	0.39		320	6.7	6.2
A-11	2.6	0.31		320	6.7	5.7
A-12	1.9	0.25		320	6.7	6.1
B-1	3.2	0.59	6.1 - 8.6	360	7.7	8.8
B-2	3.5	0.76		360	7.7	8.6
B-3	3.6	0.62		360	7.7	8.0
B-4	4.8	0.84		360	7.7	8.0
C-1	6.0	0.33	4.3 - 4.9	320	3.2	8.6
C-2	5.0	0.32		320	3.2	8.6
C-3	4.0	0.22		320	3.2	8.6
C-4	5.0	0.31		320	3.2	9.1
C-5	5.0	0.35		320	3.2	9.1
C-6	6.0	0.35		320	3.2	9.1
C-7	7.0	0.45		320	3.2	9.9
C-8	8.0	0.49		320	3.2	9.9
C-9	11.0	0.79		320	3.2	10.0
C-10	12.0	0.81		320	3.2	10.0
D-1	5.4	0.53 #	-----	315	5.9 **	6.9
D-2	5.1	0.50		315	5.9	6.9
D-3	4.4	0.46		385	5.9	6.9
D-4	4.9	0.51		385	5.9	6.9
D-5	4.2	0.44		385	5.9	6.9

*In Mill B, approximately 95% of the HCHO was found in the vents over the press, unloader and conveyors. The remaining 5% was found over the board cooler vents.

**As no data was given, this number was an average of Mills A, B, & C.

#Board densities used to calculate these values were extrapolated from Mill A & B values.

TABLE A-2. PARTIAL SUMMARY OF RESULTS OF PRESS EXPERIMENTS BY TOMAS, 1964

Run Identifier	Emission Rate (as % of excess HCHO in resin)	Emission Rate* (lb HCHO/MSF @ 3/4 in)	Press Temp (°F)	Excess HCHO (weight % [dry resin; t])	% Dry Resin (lb/100 lb BD)
C-1A	21	2.1	284	0.4	30
C-2A	14	1.8	284	0.5	30
C-3A	8	1.2	284	0.6	31
C-4A	7	1.1	284	0.6	31
C-5A	6	2.2	284	1.4	31
C-6A	4.4	3.2	284	2.8	31
C-7A	3.8	4.0	284	4.0	32
C-8A	3.4	4.9	284	5.7	31
C-1B	23	2.4	338	0.4	30
C-2B	21	2.8	338	0.5	30
C-3B	22	3.4	338	0.6	31
C-4B	17	2.6	338	0.6	31
C-5B	8	3.1	338	1.4	31
C-6B	8.2	5.9	338	2.8	31
C-7B	6.8	7.1	338	4.0	32
C-7B	6.5	9.5	338	5.7	31

*The average particle board density as calculated from data presented in NCASI Technical Bulletin No. 493, "A Survey of Formaldehyde and Total Gaseous Non-Methane Organic Compound Emissions from Particleboard Press Vents," June 1986, was used in this calculation.

APPENDIX B

TELEPHONE CONFERENCE RECORDS

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-06	Distribution White Burns
Project Name Va Formaldehyde	
Date 6-18-87	Time
Person Calling Alice Pellaud	Activity
Person Called Henry Sandonato	Activity Region 9 NYDEC Div of Air (Buffalo)
General Subject Formaldehyde emission estimates and permits for furniture manufacturing	

TOPICS DISCUSSED AND ACTION TAKEN

Henry Sandonato is the engineer in Region 9's Air office who is familiar with sources in Erie County. Three of the NATICH permits (Permit ID #'s: 140200056100005, 6, & 7) were for Tiffon Products in Buffalo. At these 3 sources they are using a gas oven wood dryer to dry laminated birch wood. The 3 dryers use 520,000 lbs. phenol formaldehyde resin per year. He gave me an example for emission estimates for one dryer that uses 206,000 lbs resin/yr. ("uses" is not the correct word - probably should say "drys x lbs. of applied resin") The resin used is 0.254 % free phenol and 0.015% free formaldehyde. The particular dryer that uses 206,000 lbs/yr operates 2000 hrs/year making resin used = 103 lbs/hr. They assumed all free formaldehyde & phenol are emitted ($103 \times 0.254 = 0.258$ and $103 \times 0.015 = 0.015$) and set the limit in the permit at 0.258 lbs/hr for phenol and 0.015 for formaldehyde. There is some burning of fumes in the gas dryer, but the ovens are otherwise uncontrolled.

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☒ Outgoing Call

Project No.	
Project Name	VA. HCHO
Date	8-18-87
Time	11:55 AM
Person Calling	TED S. WHITE
Activity	REQUEST RESIN CHEMISTRY INFO.
Person Called	DICK HUFF
Activity	TECH. SERVICE, BORDEN CHEMICAL
General Subject	TITRATION INFO. : (503) 746-8461 (WEST COAST)

Distribution
C. BURKLIN
FILE

TOPICS DISCUSSED AND ACTION TAKEN

- GEORGE WATERS ON VACATION UNTIL 08/24.
- MOST MODERN RESINS HAVE UREA ADDED AFTERWARDS
- 1:1.15 U:F GIVES A FINAL PARTICLEBOARD RESIN HAVING < 0.3 WT. % FREE HCHO.
- THE BISULFITE TITRATION AT 25 °C IS A GOOD INDICATOR OF FREE HCHO. ACCURACY DOWN TO ± 0.1% AT AN HCHO LEVEL OF 0.5 WT %. HOWEVER, SPECIFIC PROCEDURES MUST BE FOLLOWED.
- BORDEN HAS DEVELOPED THESE PROCEDURES; THEY'RE PROPRIETARY
- AS CROSSLINKING OCCURS, SOME FREE HCHO IS KICKED OUT.

(OVER)

Signature Ted S. White

- DURING COOKING, IF YOU START WITH A CHEMICAL SOLIDS CONTENT OF 84%, YOU END WITH A CHEMICAL SOLIDS CONTENT OF 64% BECAUSE WATER AND HCHO ARE KICKED OUT DURING THE COOK.

- THE RESULTS OF THE TITRATION PROCEDURE ARE ONLY BASED ON THE "DRY" RESIN SOLIDS TITRATED.

- WATER IS NOT LIBERATED DURING THE TITRATION PROCEDURE.

- TITRATION IS SENSITIVE TO RESIN TEMP., TIME OF TITRATION, AND pH OF RESIN TITRATED.

- THE DIFFERENCE IN NUMBERS YOU GET BETWEEN 0°C AND 25°C MIGHT BE 1%, BUT NOT 10%.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALDEHYDE
Date	7-22-87
Time	3:00 PM
Person Calling	TED WHITE
Activity	
Person Called	DON BARRIER
Activity	GEN. MANAGER - SOUTHEASTERN
General Subject	ADHESIVES 1-804-956-3176

Distribution
C. BURKLIN
FILE

TOPICS DISCUSSED AND ACTION TAKEN

- THREE BASIC SULFITE TITRATIONS ARE USED:
  a) 80°C
  b) 25°C
  c) 0°C
  } USED AS Q.C. INDICATOR ONLY; CHEMISTRY IS SO COMPLEX THAT NO ATTEMPT IS MADE TO PREDICT FREE F.

  -EACH GIVES VASTLY DIFF. ANSWER ON FREE HCHO, DEPENDING ON HOW U:F RETIN IS MADE.

- NOWADAYS, RESIN MANUFACTURERS WILL ADD 1.3-1 F:U INITIALLY, REACT THROUGH A SERIES OF pH ADJUSTMENTS AND THEN ADD ENOUGH UREA AT END TO TIE UP EXCESS F IN LINEAR CHAINS.

- THE 0°C TITRATION (SULFITE) PROBABLY GIVES YOU THE CLOSEST APPROX. TO THE AMOUNT OF MOLAR EXCESS F WHICH YOU STARTED WITH IF YOU USE THE MANUFACTURING PROCESS ABOVE, BECAUSE IT WILL BREAK DOWN THE LINEAR CHAINS (DURING TITRATION).

- 25°C TITRATION WILL GIVE YOU ABOUT 10 TIMES THAT HCHO

Signature Ted A. White

(OVER)

- DON SAID THAT ONE OF THE REASONS EVERYBODY WAS SO CLOSE-MOUTHED AT THE MEETING IS BECAUSE THE MOLAR XCESS F YOU START WITH, FOR INSTANCE, IS A VERY PROPRIETARY NUMBER. SMALL DIFFERENCES IN THAT MAKE A BIG DIFFERENCE IN THE FINAL PRODUCT PROPERTIES.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALDEHYDE
Date	6-11-87
Time	3pm
Person Calling	T. WHITE
Activity	
Person Called	BILL GROAH
Activity	HARDWOOD - PLYWOOD MANU. ASSOC.
General Subject	(703) 435-2900

Distribution: C. BURKLIN, A. PELLAND, FILE

TOPICS DISCUSSED AND ACTION TAKEN

- FURN. MANUFACTURER MAY APPLY LIQUID DECORATIVE SURFACE TO ALREADY FORMED BOARDS, OR APPLY A FILM SUCH AS POLYVINYL ACETATE
- SOME FURN. MANU. MAKE OWN PLYWOOD
- FACTORY HCHO SOURCES:
  - HOT PRESS (INTERFACE TEMP. = 250°F (RANGE 225-275°
  - GLUE SPREADER
  - FINISH RM. (COOLING)
  - WAREHOUSE
- 8-PLANT OSHA SURVEY AVAIL. (CONCENTRATIONS ONLY)
- REFORMULATIONS:
  - MORE OR LESS FILLER (IE FLOUR), WATER, CATALYST
- LOW EMITING RESINS EMIT 10-20% OF THE HCHO WHICH WAS EMITING 8 YEARS AGO
- STANDARD RESINS EMIT 33-50% LESS THAN 8 YRS AGO
- RESIN COMES ON SITE IN LIQUID FORM, 60-65% SOLIDS, PEOPLE ADD H_2O TO THAT BEFORE USE.

-OVER-

Signature

- TWO TYPES PRESSING TECHNIQUES USED IN FURNITURE :

  COLD PRESS : OVERNIGHT CURE
  HOT PRESS : 1-2 MINUTES CURE

  RESINS TODAY F : U MOLE RATIO

  1.3 : 1

  8 YEARS AGO : 1.8 : 1

- ANOTHER SOURCE OF HCHO IN FURN. MANUFACTURE :

  ALKYD - UREA SYNTHETIC VARNISH BLENDS.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALD.
Date	6-12-87
Time	7 PM
Person Calling	GEORGE WATERS
Activity	(RETURNING CALL)
Person Called	T. WHITE
Activity	TECH. SERVICE REP., BORDEN CHEMICAL
General Subject	(503) 746-8461

Distribution: C. BURKLIN, A. PELLAND, FILE

TOPICS DISCUSSED AND ACTION TAKEN

- GEORGE GAVE ME ONE DATA POINT & SAID HE'D GET BACK WITH MORE INFO.

IN THE WORST CASE, EMISSIONS OF HCHO IN HARDWOOD-PLYWOOD MANUFACTURE WERE 5.5 lb/1000 ft² (3/4" BASIS) OUT OF THE PRESS VENT STACKS (2-9, RANGE) USING A 1.7 : 1 MOLE RATIO ~~F~~ F : U RESIN

- ALSO THE ~~&~~ PHENOL-FORMALDEHYDE RESINS EMIT ABOUT 2/3 THAT AMOUT OUT OF THE PRESS VENT STACKS.

- HE'LL CALL BACK W/MORE INFO ON 6-19-87

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	Distribution: C. BURKLIN, A. PELLAND, FILE
Project Name: VA. FORMALDEHYDE	
Date: 6-12-87	Time: 3 PM
Person Calling: T. WHITE	Activity
Person Called: HAROLD PODALL	Activity: EPA RESEARCHER
General Subject: (202) 382-3682	

TOPICS DISCUSSED AND ACTION TAKEN

- LOOKED AT TWO HARDWOOD-PLYWOOD PLANTS (BOTH IN VA.)
- GERMANS ARE AHEAD OF USA IN DEVELOPING STDS., FOR INSTANCE: F:U MOLAR RATIOS THERE ARE ON ORDER OF 1.2:1, USE ALONG WITH AN HCHO SCAVENGER SUCH AS UREA, WAX, SURFACTANT MIXTURE UPSTREAM OF THE GLUE SPREADER.
- APPLY AMMONIUM SOLUTION SCAVENGER TO BOARDS TO SCAVENGE DEGASSING HCHO PRIOR TO STORAGE, & DEGREE OF STACKING IS CAREFULLY CONTROLLED.
- MODERN U+F RESINS HAVE < 0.5% FREE HCHO, F:U DOWN TO 1.2:1 TODAY, ESP. AMONG LARGER COMPANIES.
- MOST OF THIS FREE HCHO TAKEN UP DURING CROSSLINGING

Signature

-OVER-

- FREE HCHO PRESENT AFTER CROSSLINKING MAY BE < 0.05 % OF INITIAL RESIN.

- CONTACT : GEORGE MYERS
  PAPER INSTITUTE
  APPLETON, WI.
  (608) 264- 5130
  -OR- - 5678

- DR. JIM WILLIAMS OF BORDEN HAS A PATENT ON A NEW UHF RESIN WITH A F : U VERY LOW,

  QUANTITY OF FREE HCHO < 0.1 %

- LARGER WOOD CO's HAVE GONE OVER TO LOWER MOLE RATIOS.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALD.
Date	6-12-87
Time	11 AM
Person Calling: T. WHITE	Activity
Person Called: JEANE SKIEST	Activity: RESIN CHEMIST - BORDEN CHEMICAL
General Subject: (614) 431-6619	

Distribution: C. BURKEL, A. PELANT, FILE

TOPICS DISCUSSED AND ACTION TAKEN

- USUALLY, EACH CUSTOMER HAS A RESIN "TAILOR-MADE," ALMOST
- MOLAR RATIOS HAVE BEEN REDUCED TO 1.15 : 1 F : U
- AMMONIA FUMIGATION IS USED FOR FINISHED BOARD EMISSION CONTROL - EXPENSIVE PROCESS
- MDF (MEDIUM DENSITY FIBERBOARD) MOLE RATIO HAS NEVER BEEN ABLE TO COME DOWN.
- U-F RESINS ARE LOWEST COST, FOLLOWED BY MELAMINE-F TYPE
- P-F GIVES QUANTUM JUMP IN PRICE
- ALSO, P-F GLUES TEND TO BLEED OUT & DARKEN SOME HARDWOODS.
- IN SOME RESINS, THE CATALYST IS BUILT IN. IN SOME, THE CATALYST IS ADDED BY THE USER.

B-12 (COVER)

- SOMETIMES, A LOWER EXCESS HCHO WILL GIVE YOU HIGHER EMISSIONS BECAUSE THE EXTENT OF REACTION IS SO POOR WITH VERY LOW F:U RATIO RESINS.

LOWER LIMIT MOLAR RATIO IS ABOUT 1.2 : 1 F : U

- CONTACT :

GEORGE WATERS
BORDEN CHEMICAL
(WEST COAST) CLOSE TO CUSTOMERS
(503) 746 - 8461

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMAL.
Date	6-12-87
Time	8:30 AM
Person Calling	T. WHITE
Person Called	BILL MCCREDIE
Activity	
Activity	V.P. NATIONAL PARTICLEBOARD ASSOC.
General Subject	(301) 670-0604

Distribution:
C. BURKLIN
A. PELLANI
FILE

TOPICS DISCUSSED AND ACTION TAKEN

- OF FREE HCHO IN RESIN
  - SOME LOCKED UP DURING CURING - CROSSLINKING.
  - SOME EXHAUSTS DURING MANUFACTURING.
  - SOME EMITS OVER LONG PERIOD OF TIME.

- ONE STUDY DONE BY NCASI ON PARTICLEBOARD PLANTS

- TECHNICAL CONTACT IN FURNITURE:
  RUNYAN - FURNITURE MANU. ASSOC.
  HIGH POINT, N.C.

- FURNITURE MANU.'S USUALLY ADD DECORATIVE TO BASE, SUCH AS PHOTOGRAPH - REPRODUCED SHEET. MELAMINE - TYPE (M-F) RESINS ARE PRIMARILY USED FOR SOLID COLOR SHEETS.

- OVER -

Signature

B-H

3 TECHNICAL CONTACTS :

1. LARRY NEWTON - RESIN CHEMIST
   GEORGIA PACIFIC (404) 981-3220 (ATLANTA)

2. DICK JEWELL - RESIN EXPERT
   WEYERHAUSER, TACOMA, WA.
   (206) 924-6451

3. JEANE SKIEST - RESIN CHEMIST
   BORDEN CHEMICAL : COLOMBUS, OH
   (614) 431-6619

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-06	Distribution T. White
Project Name VA formaldehyde	
Date 6-12-87	Time 1:40PM
Person Calling Alice Pellandi	Activity
Person Called Charles Holmes	Activity 804-786-4567
General Subject Telecon VA permit files on formaldehyde emissions from furniture manufacturing	

TOPICS DISCUSSED AND ACTION TAKEN

page 1 of 3

I called Charles Holmes to ask what information the State had in permit files that would be useful the formaldehyde control from furniture plants project. Charles explained that they have had no new permit applications since their toxic rule went into effect and that most furniture plants are existing sources. Hence, there are no files on formaldehyde emissions.

I asked about the resins in use and he said they were able to understand the formulations in the material safety data sheets (MSDS). He said there are 2 groups of resins in use:

(1) Low formaldehyde resins. These have about ½ of 1 percent free formaldehyde, based on sulfite titration at 25°C. The titration tests are done by suppliers and reported to buyers.

(2) High formaldehyde resins. (most common) - these have 2-5 percent free formaldehyde in the resin. This was the basis for their emission estimate. No stack tests have been done.

p 2 of 3
6-12-97
Pollard

I asked if the State had any records Charles felt would be useful for us. He said that a plant making 3/4" plywood had done a stack test. The plant used alot of formaldehyde but low met the toxics standard. Charles is sending this information today Federal Express. (He's also sending the air toxics rep.)

I asked Charles specifically where presses remaining come from in furniture manufacturing. He explained that most formaldehyde is emitted in hot press rooms where the veneer is put on the base stock. Some is emitted in other gluing processes such as the gluing of chair legs to seats, but most is emitted in the hot press rooms.

In the States inventory, the State asked manufacturers what their highest formaldehyde emissions were for a 24-hour period. This was met with resistance from manufacturers so the State got MSDS and calculated based on the formaldehyde in the resin. They used the assumption that 100% of the free formaldehyde is emitted.

Portland

In permitting a new source, the state should require stack testing to ensure that the facility met the emission limit. Presently for existing sources they do not require stack tests, but Charles said they may in the future.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALD.
Date	6-15-87
Time	11:30 AM
Person Calling	T. WHITE
Person Called	JOHN EMERY
Activity	
Activity	AMERICAN PLYWOOD ASSOCIATION
General Subject	(206) 565-6600 TACOMA, WA.

Distribution:
C. BURKLIN
A. PELLAND
FILE

TOPICS DISCUSSED AND ACTION TAKEN

- JOHN HAD NO REAL INFO., AS THEY DEAL PRIMARILY WITH THE P-F RESINS.

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALDEHYDE
Date	6-15-87
Time	2PM
Person Calling	T. WHITE
Activity	
Person Called	GEORGE MYER
Activity	RESEARCHER - APPLETON PAPER INSTITUTE
General Subject	(608) 264-5678

Distribution:
C. BURKLIN
A. PELLAND
FILE

TOPICS DISCUSSED AND ACTION TAKEN

- HAS 3 GERMAN ARTICLES ON PARTICLEBOARD HCHO EMISSIONS DURING MANUFACTURE, 2 TRANSLATED.
- WILL SEND COPIES.
- ALSO, HE GAVE THIS REFERENCE:

R. MARUTZKY, L. MEHLHORN, H.A. MAY
HOLZ AUS ROH- UND WERKSTOFF
VOL 38, 1980 pp. 329-335

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALD.
Date	6-15-87
Time	1:30 PM
Person Calling	T. WHITE
Person Called	DICK JEWELL
Activity	
Activity	RESIN EXPERT - WEYERHAEUSER TACOMA, WA.
General Subject	(206) 924-6451

Distribution: C. BURKLIN, A. PELLANT, FILE

TOPICS DISCUSSED AND ACTION TAKEN

- CURRENT VA. ASSUMPTION OF HCHO EMITTING (100% OF FREE IN RESIN) IS NOT AT ALL GOOD
- P-F's ⇒ HIGHER PRESS TEMPS.
  U-F's ⇒ LOWER PRESS TEMPS.
- LEVELS IN MILLS HAVE GONE DOWN WITH THE BETTER RESINS.
- SOURCES OF RESINS:
  - CHEMBOND
  - BORDEN

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-00	Distribution
Project Name Va. Formaldehyde	
Date 6-16-87	Time
Person Calling Alice Pelland	Activity
Person Called Dave Prosser (315) 785-2513	Activity NYDEC - Regional Air Poll. Cntl. Engineer
General Subject Formaldehyde emissions from furniture manufacture	

TOPICS DISCUSSED AND ACTION TAKEN

Based on the NATICH print out of furniture manufacturing permits that address formaldehyde, I called John Davis in the NYDEC air office. John wasn't there, (out Fri 6/19/87) but I was referred to a gentleman who recommended I call one of the regional air pollution control engineers, specifically Dave Prosser in Boonesville (Region 6).

Mr. Prosser said there is only one furniture plant in his 6-county region: Harden Furniture. This plants makes only solid wood cherry furniture. All they do is spray the finished piece but do not use a urea/formaldehyde spray.

It was apparent to Mr. Prosser that the permets listed were not in his region. He said the first two digits of the permit ID represent the County and the remaining 13 digits represent the plant location & source. He suggest I call two men in Albany for more information and to see who the contacts are for the permets listed by NATICH.

Signature

(OVER)

These 2 people are:

Jim Harrington and Don Spencer
(518) 457-2044

Both are out until 6/17/87. They provide technical assistance to the regions and may familiar with permiting wood furniture manufacturers and the manufacturing process.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-06	Distribution
Project Name VA. Formaldehyde	
Date 6/16/87	Time
Person Calling Alice Pelland	Activity
Person Called Don Sheppard	Activity VA. SAPE B - Regional Engineer R3 - Roanoke
General Subject Furniture Manufacturing	

TOPICS DISCUSSED AND ACTION TAKEN

Charlie Holmes suggested I call Mr. Sheppard to ask which furniture manufacturers would be good contacts.

Mr Sheppard said none of the furniture manufacturers know much about formaldehyde emissions but I reiterated our interest in the manufacturing process. Then he suggested I start with Dick McDonald of Singer Furniture and then try anyone who attended the State's two meetings. He also suggested trying Southern Adhesives, an adhesives producer.

Of the manufacturers attending the meetings, he explained, most formaldehyde emissions come from veneer application.

Mr. Sheppard also suggested I call another regional engineer, Mike Overstreet, (703) 628-7841.

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-00	Distribution
Project Name VA. Formaldehyde	
Date 6/16/87	Time
Person Calling Alice Pelland	Activity
Person Called Tom Henderson	Activity Region 3 - Va SAPCB (Lynchburg)
General Subject Formaldehyde emissions from furniture manufacturing	

TOPICS DISCUSSED AND ACTION TAKEN

Charlie Holmes (Va. SAPCB) suggested I call Tom because he would familiar with furniture Company Contacts in his region.

Mr. Henderson suggested I call:

* Stanley Furniture - Alex Teglas
  Lane - Ken Wright
  American - Jerry Marlowe

He explained several manufacturers had gotten together to discuss the formaldehyde questions. All 3 of these attended both the Oct. & March meetings.

This was organized by Alex Teglas, I believe.

* One contact in a Regional office said Stanley was not a good contact because they supplied misinformation in the past.

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	Time
239-003-06	
Project Name: VA FORMALDEHYDE	
Date: 6/16/87	
Person Calling: Alice Pelland	Activity
Person Called: Denese Kimball	Activity: Regional Office VA. Air Pollution Control Board

General Subject: Furniture plants to contact in this Region

TOPICS DISCUSSED AND ACTION TAKEN

Charlie Holmes (Va SAPCB) suggested I call two regional engineers and one of those suggested I call Mike Overstreet, another Va. SAPCB regional engineer. Mr. Overstreet was not in today so I was referred to Denise Kimble. Ms. Kimble was not familiar with the furniture manufacturing processes or the pollutant free formaldehyde used by furniture plants in the region, but she checked the files and called me back with the following contacts:

State reg. no.	Name/Contact
10332, 10538	Webb Furniture Enterprises #1 & #2 Barry Branscome (703) 236-2984
10443, 10159	Vaughn Furniture Co. Galax, Va. Nick Moody or George Sanders (703) 236-6111
10424	Virginia House Furniture Co. Mr. Spanger (703) 783-7217

OVER

[Webb Furniture and Vaughan Furniture were represented at the Oct. 14 and March 26 meetings by the following:

Webb = Neil Bordeaux
Vaughan = Press Shirley Hill]

(This was based on the list of attendees; not from Ms. Kimble.)

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-06	Distribution
Project Name Va. Formaldehyde	
Date 6/16/87	Time
Person Calling Alice Kelland	Activity
Person Called Dick McDonald (704) 728-6741	Activity Serger Furniture Co.
General Subject Furniture manufacturing process description	

TOPICS DISCUSSED AND ACTION TAKEN

Don Sheppard suggested I call Dick McDonald. Mr. McDonald was out and will call back on 6/17/87.

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-06	Distribution
Project Name Va. Formaldehyde	
Date 6-16-87	Time
Person Calling Alice Pelland	Activity
Person Called Ken Wright (804) 369-5641	Activity Lane Furniture Co.
General Subject Details on manufacturing process	

TOPICS DISCUSSED AND ACTION TAKEN

Mr. Wright is on vacation this week.

Signature

B-28

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-06	Directions:
Project Name VA Formaldehyde	
Date 6/16/87	Time
Person Calling Celia Pelland	Activity
Person Called Jerry Meaux Thorton	Activity Facility Engineer - American Furniture
General Subject Description of manufacturing process	

TOPICS DISCUSSED AND ACTION TAKEN

I was advised by Tom Henderson - Region 3 - Va. SAPCB to call Jerry Marlow at American Furniture Co. in Martinsville, Va. Mr. Marlow was out of town this entire week so I was told to talk with Mr. Thorton. (Jerry Marlow attended both the Oct 14 1986 & March 26, 1987 Virginia "formaldehyde meetings," but Mr. Thorton did not.)

Mr. Thorton explained he is the facility engineer and not as familiar with production as Mr. Marlow. In response to my questions Mr. Thorton gave the following answers:

① the average thickness of the glue is about 0.03 inch, he estimated

② he didn't know the amount of glue used.

③ for application, the glue is in a glue spreader. It is mixed continuously and applied with a series of rollers "like an old fashioned wringer washing machine." It is a continuous refill of the spreader which probably refills about 8 times per day.

Signature

(over)

④ It is a matter of minutes before the next layer is put on the surface coated with glue.

⑤ The materials then pressed in a heated press (290°F) for one minute.

⑥ Mr. Thorton didn't know the percent-free formaldehyde or percent solids in the glue. He said the State has that on the Material Safety data sheet.

Mr. Thorton suggested I call Alex Teglas at Stanley Furniture Co. He said Stanley has the same kind of process. He also said he was sorry he didn't know more about the process and encouraged us to visit a plant.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	Distribution: C. BURKLIN, A. PELLANO, FILE
Project Name: VA. FORMALDEHYDE	
Date: 6-17-87	Time: 2:15 PM
Person Calling: T. WHITE	Activity
Person Called: LARRY NEWTON	Activity: RESIN CHEMIST - GA. PACIFIC (RESIN SUPPLIER)
General Subject: (404) 981-3220 ATLANTA	

TOPICS DISCUSSED AND ACTION TAKEN

- DURING FURNITURE MANUFACTURE, HE FOUND THAT THERE WERE 3 MAIN EMISSIONS POINTS:

  - ADHESIVE ITSELF (GLUE SPREADING)
  - EMISSIONS DURING CURING (HOT, COLD PRESS)
  - FINISHING STEPS (COOLING, CUTTING ROOMS)

- HE DID SOME EMISSIONS WORK IN A FURNITURE PLANT, & WILL GET THE INFO. TO ME ON 6-18-87.

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-06	Distribution White Burden
Project Name Va. Formaldehyde	
Date 6-17-87	Time
Person Calling Alice Pelland	Activity
Person Called Don Parish (804) 369-5641	Activity Lane Furniture Co.
General Subject Furniture manufacturing process	

TOPICS DISCUSSED AND ACTION TAKEN

Mr. Parish was very glad that someone was working on the issue of estimating formaldehyde emissions from furniture manufacturing. He said the main thing puzzling all the furniture manufacturers is how much gaseous formaldehyde goes up the stack. Mr. Parish maintains it is not 100% emitted, but some stays in the product. He feels it varies depending on the process. There are three main processes:

(1) manufacture of particleboard using urea/formaldehyde resin. (Most furniture companies buy particleboard so he said this process is not a factor.)

(2) gluing veneer on particleboard

Mr. Parish didn't know the average glue thickness or amount per ft^2, but he will get back with me after checking with QC person. He didn't think anyone had measured glue thickness.

Lane Furniture applies the glue to the veneer by putting the veneer through glue rollers with the glue pot above. As the rollers turn the glue is applied to the veneer. Veneer size depends on the piece of furniture being made. For instance,

they would put glue on veneer for a bed head board rather than a continuous piece.

The veneer with glue on it is only exposed to the air for less than one minute. The veneer comes out of the rollers and people lay the veneer on the particle board right away. They also use layers of cross ban veneer.

Next the pieces go down a gravity feed roller conveyer for a distance of about 10 feet. They set there a short while and then are pressed between aluminum plates in a hot plate press. The press has a large hood that pulls emissions out of the workplace and vents them up the stack.

Lane purchases dried veneer for the most part but does make and dry cedar veneer. They soak the logs & then slice it into veneer. It is air dried. One plant makes some cross ban veneer from poplar. It is dried in ovens - I believe he said before it's cut.

Mr Parish gave me another contact at Lane for glue composition. He did explain that one time they've work with Borden, their glue supplier, who has developed a U/F resin that is lower in free formaldehyde. For some applications, Lane found it good, but for others it was not good. Their machines wouldn't run properly. Now Borden has improved it and Lane's entire plant will be converting.

Mr. Parish plans to attend the 6/25/87 meeting. He said there's a Baptist Convention in Richmond at that time and people are having a hard time finding rooms.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No. 239-003-06	Distribution White Buff
Project Name Va. Formaldehyde	
Date 6-17-87	Time
Person Calling Alice Pelland	Activity
Person Called Don Spencer NYDEC	Activity (518) 457-2044 (Albany)
General Subject formaldehyde emission estimating techniques & permits for furniture manufacturing	

TOPICS DISCUSSED AND ACTION TAKEN

Don Spencer is in the Albany headquarters for NY's air office. I asked him which regional office had issued the permits we located on NATICH for formaldehyde emissions from furniture manufacturing. (They have 9 regions plus NYC has an air program.) Five were from NYC and two were from Erie Co. (Region 9). He said not to try to call NYC but that the contact in Region 9 is Stan Yukevich (716) 847-4565.

They have no standard way state-wide to estimate formaldehyde emissions from furniture plants. He said a permit applicant would do a mass balance and different applicants may use different assumptions.

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALDEHYDE
Date	6-18-87
Time	11:40 AM
Person Calling	T. WHITE
Person Called	TIM REID
Activity	
Activity	PRODUCTION - MASONITE CORP. VA
General Subject	(804) 834-7201 (PARTICLEBOARD MANUFACTURER)

Distribution: C. BURKLI, A. PELLAND, FILE

TOPICS DISCUSSED AND ACTION TAKEN

- PARTICLEBOARD INDUSTRY IS NOW GENERALLY BELOW 1.1 : 1, F : U. IN-PLANT SCAVENGERS ARE USED WHICH HELP TO REDUCE EMISSIONS ALSO. THE PLANT WILL ADD THE SCAVENGERS IN.

- THEIR HOT PRESS OPERATES AT 350°F

- TIM DOES A YEARLY MASS BALANCE FOR THE STATE OF VA. ON HCHO, BY TAKING FAIRLY SCIENTIFICALLY-DERIVED CURVES OF HCHO VS. TIME FOR DIFFERENT BOARDS, INTEGRATING THEM TO GET THE TOTAL HCHO OFF-GASSED (UP TO 2 MONTHS), AND ADDING THIS NUMBER TO THE AIR TEST NUMBERS HE GETS OFF THE PRESS VENTS AS A ROUGH CHECK ON THE AMOUNT OF FREE HCHO BEING ADDED INTO A BOARD.

NOTE: A SUBSEQUENT CALL ON 6-19 TO CLARIFY THIS WAS NOT WELL RECIEVED BY TIM. HE CONTRADICTED MUCH OF THIS.

-OVER-

- AFTER 2 MONTHS, THE AMT. OF HCHO EMITTED FROM A BOARD IS ASSUMED TO BE DUE TO HYDROLYSIS OF THE HCHO - UREA BONDS RATHER THAN ACTUAL RESIDUAL FREE HCHO.

- THEIR PRESS SIZE IS 5' x 16'.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALDEHYDE
Date	6-18-87
Time	9:30 AM
Person Calling	T. WHITE
Activity	
Person Called	BILL GROAH
Activity	HARDWOOD-PLYWOOD MANU. ASSOC.
General Subject	(703) 435-2900

Distribution:
C. BURKLIN
A. PELLAND
FILE

TOPICS DISCUSSED AND ACTION TAKEN

- THE MANUFACTURED HOUSING INSTITUTE FOUND THAT THE HIGHEST HCHO CONC's FOUND WERE IN A TEXTILE FINISHING STEP OF A DRAPERY PLANT

- PROCESSING STEPS IN H-P MANUFACTURE (AND, INCIDENTALLY IN SOME FURNITURE PLANTS):
  - GLUE IS APPLIED TO BOTH FRONT & BACK OF A LAMINATE BY A DOUBLE-ROLLER SYSTEM:
    - A 3 PLY HAS 1 PIECE COATED F & B
    - A 5 PLY HAS 2 PIECES COATED F & B
    - etc.
  - PRESSES ARE HYDRAULIC, A LITTLE LARGER THAN 4' x 8', WITH AN ELEVATED LOADING PLATFORM
  - THE PLATENS NUMBER 10-20, THE NUMBER USED DEPENDING ON THE THICKNESS, GENERALLY, OF THE MATERIAL BEING PROCESSED.

-OVER-

B-37

- PRESS IS CLOSED, HEATED BY STEAM, 150 PSI (RANGE 125-175)

- THE OBJECTIVE IS TO HAVE THE INNERMOST GLUELINE REACH A SPECIFIED TEMP. FOR A SPECIFIED PERIOD OF TIME.

- AN EXHAUST FAN COMES ON AUTOMATICALLY WHEN TAE PRESS IS OPENED, TO PROTECT THE WORKERS.

- THE FINISH ROOM WILL USUALLY BE PARTITIONED FROM THE REST OF THE PROCESS TO PROTECT THE FINISHING STEP FROM PARTICULATES, ETC.

- PRESS CYCLE:

  THIN PANELS: 2.5 - 3 MIN (3/8" - 1/2" THICK)
  THICK PANELS: 8 - 10 MIN (7/16" - 3/4" THICK)

  75% OF THESE TIMES ARE USED TO PRESS, AND 25% TO GLUE & LOAD. GLUEING USUALLY TAKES ABOUT 30 SEC.

- THERE IS SOME CONVEYORING OF THE MATERIAL, BUT AFTER VENEER DRYING, EVERYTHING IS BATCH WISE.

Ted

RADIAN CORPORATION

CONTACT REPORT

Date 6/18/87 Originator Burkli

CONTACT BY: TELEPHONE ☒ MEETING ☐ Other

NAME, TITLE & ORGANIZATION

Don Barrier Southeastern Adhesives

ADDRESS & TELEPHONE NUMBER

(703) 956-3176

PURPOSE OR SUBJECT (Give project number if appropriate)

SUMMARY. There are many good formulations w/ formaldehyde below 2%

- Free formaldehyde important to cross linking but can be replaced w/ proper catalyst (a "faster" + "hotter" catalyst)
- The catalysts are mineral salts like ammonium ~~sulfate~~ chloride
- Scavengers like ammonia or sulfide compounds can tie up free formaldehyde.
- They cross link an adhesive - so for, raise pH, and cell the resin. The ~~resultant~~ furniture plant lowers pH & re-initiate polymerization - and uses heat to speed it up
- One problem w/ ~~experimental formulat~~ excess catalyst is too rapid polym initiation

ACTION

9815676

Distribution:

over

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO. _____

SIGNATURE _____ DATE _____ CHECKED _____ DATE _____

PROJECT _____ JOB NO. _____

SUBJECT _____ SHEET _____ OF _____ SHEETS

The state of NC is doing some emission study on formaldehyde formulations. We should call them.

4813361

RADIAN CORPORATION

CONTACT REPORT

Date 6/18/87 Originator Burkling

CONTACT BY: TELEPHONE ✓ MEETING ☐ Other

NAME, TITLE & ORGANIZATION

John Murray Formaldehyde Inst

ADDRESS & TELEPHONE NUMBER

(202) 659-0060

PURPOSE OR SUBJECT (Give project number if appropriate)

SUMMARY

He knows of no sources of emission data on hardwood plywood or ~~F~~ furniture anywhere

He recommends we contact Gen Cor & Georgia Pacific - Atlanta (404) 981-3220

ACTION

9-81-5676

Distribution:

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	Distribution
239-003-06	White Berglin
Project Name: Va Formaldehyde	
Date: 6-18-87	Time:
Person Calling: Celeca Pillard	Activity:
Person Called: Lowell Yatts (804) 369-5641	Activity: Lane Furniture Co.
General Subject:	

TOPICS DISCUSSED AND ACTION TAKEN

I called Mr. Yatts (pronounced Yates) at the recommendation of Jon Parish at Lane because Mr Parish felt Mr. Yatts would be familiar with the composition of the glue. Mr Yatts did not know the percent free formaldehyde. He said it does not play a role in the quality testing he does. If they need to know, they can get the information from Borden, their supplier. Lane buys resins from Borden and then adds a catalyst to lower the pH to about 5.5. That pH level along with the heat of the press causes the glue to cure faster. It could be cured with heat alone but it would be slower.

I asked about the temperature of the hot press. He said they have 3 presses. One uses a temperature of 280 to 300°F and pieces stay in for 45 seconds to 3 minutes. The other two presses operate at a temperature of 250 to 260° F and pieces stay in for about 5 minutes. The length of time varies with the piece of furniture due to the number of plys. (3ply is quicker than 5ply.) The heat must penetrate the innermost glue line and that glue line must reach boiling point (as measured w/a thermocouple.

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALDEHYDE
Date	6-19-87
Time	2:30 PM
Person Calling	T. WHITE
Person Called	GEORGE WATERS
Activity	
Activity	RESIN TECH SERVICE - BORDEN CHEMICAL
General Subject	(503) 746-8461 (WEST COAST)

Distribution:
C. BURKLIN
A. PELLAND
FILE

TOPICS DISCUSSED AND ACTION TAKEN

- IN FURNITURE MANUFACTURE, HE BELIEVES THAT EMISSIONS WOULD BE A FRACTION OF PARTICLEBD., BECAUSE FURNITURE MANUFACTURERS GENERALLY ADD CATALYSTS IN THE PLANT AS HCHO INHIBITORS.

- HIS WORST CASE DATA POINT AS MENTIONED IN A PREVIOUS PHONE CALL, WAS A RESIN WITH A 1.6 : 1 TO 1.7 : 1 F : U MOLAR RATIO WHICH GAVE 9 lb/MSF (7/16") HCHO PRESS VENT EMISSIONS FROM A PARTICLEBOARD FACILITY AS REPORTED IN THE NCASI TECHNICAL BULLETIN. THE RESIN USED (BORDEN'S) CONTAINED NO EXTERNAL CATALYSTS OR 'SOD'

- CATALYST IS GENERALLY A DRY POWDER ADDED AT THE PLANT IN A TYPICAL RATIO OF 20 PARTS / 100 PARTS RESIN. THE UREA AND AMMONIUM CHLORIDE (OR SALTS) WILL EACH BE ABOUT 5% OF THE TOTAL RESIN AFTER ADDITION. THESE TWO COMPOUNDS

(OVER)

ARE PART OF THE CATALYST.
OTHER PARTS ARE:

a) FILLER (SUCH AS WOOD FLOUR)

b) HARDENER STARCH (" WHEAT FLOUR)

" THERE ARE 1001 POWDER MIXES OUT THERE, DEPENDING ON THE APPLICATION".

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☒ Outgoing Call

Project No.	
Project Name	VA. FORMALDEHYDE
Date	7-17-87
Time	11:45 AM
Person Calling	TED WHITE
Activity	REQUEST RESIN CHEMISTRY INFO.
Person Called	GEORGE WATERS
Activity	TECH. SER. REP., BORDEN CHEMICAL
General Subject	(503) 746-8461 (WEST COAST)

Distribution: C. BURKLIN FILE

TOPICS DISCUSSED AND ACTION TAKEN

o FREE HCHO DOWN TO 0.1 %, TOTAL HCHO MIGHT BE 30 %, SOME FORMULATIONS

o SOME HCHO KICKED OFF DURING CURING

3 DIFF METHODS THEY USE:

a) ICE METHOD (WAIT FOR EQUILIBRIUM AT ZERO DEGREES C)

[HE DIDN'T GIVE ME THE OTHER TWO METHODS]

o RESIN SYSTEMS ARE NOT THAT DIFF. BETWEEN PARTBOARD & FURNITURE, EXCEPT FOR % FREE HCHO, CURING TEMPS. & CATALYST SYSTEMS:

- SOME RESINS HAVE MELAMINE, AMMONIA (FOR PARTBOARD)
- MOST FURNITURE RESINS ARE SIMPLE, NOT MANY COMPLICATING FACTORS SUCH AS CATALYSTS & THE ABOVE COMPOUNDS -

o - IN GEORGE'S OPINION, THE ASSUMPTION OF FREE HCHO (SULFITE TITRATION) ≡ FREE HCHO (MOLAR) IS A PRETTY GOOD ONE, ESP. FOR FURNITURE RESINS. (AND MUST P.BD. RESINS) Signature Ted O. White

o (GEORGE WAS NOT FORTHCOMING ON HOW MUCH TEMP. AFFECTS THE TITRATION RESULTS)

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name: Va. FORMALDEHYDE	
Date: 7-17-87	Time: 10:10 AM
Person Calling: TED WHITE	Activity:
Person Called: JEANE SKIEST	Activity: RESIN CHEMIST- BORDEN CHEMICAL
General Subject: (614) 431-6619	

Distribution: C. BURKLIN FILE

TOPICS DISCUSSED AND ACTION TAKEN

- ONE MOLE OF UREA HAS POTENTIALLY 4 SITES.

- FEELS MORE COMFORTABLE WITH THE TITRATION THAN WITH MOLAR EXCESS, BECAUSE THE TITRATION GIVES YOU THE ACTUAL AMOUNT OF FREE HCHO, WHEREAS MOLAR RATIO DOES NOT ACCOUNT FOR ALL OF THE SIDE REACTIONS WHICH COULD TAKE PLACE DURING THE MANUFACTURING PROCESS, FOR INSTANCE, ONE UREA TYING UP TWO HCHO's (GIVING A DIMETHYLOL UREA).

- RESIN IS CROSS-LINKED PARTIALLY PRIOR TO BEING SHIPPED. TITRATION IS GENERALLY DONE AS A Q.C. ~~FOR~~ FOR FREE HCHO JUST PRIOR TO SHIPPING. SOME MANU'S PUT THIS NO. ON THE MSDS's.

- JEANE DID NOT KNOW MUCH ABOUT THE TITRATION ITSELF, I.E., HOW TEMP. AFFECTS RESULTS.

Signature: Ted A. White

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALDEHYDE
Date	7-28-87
Time	11:00 AM
Person Calling	TED WHITE
Activity	
Person Called	VICTOR DALLONS
Activity	NCASI, CLARIFY
General Subject	(503) 754-2015 ITEMS IN PARTICLEBOARD HCHO REPORT

Distribution
C. BURKLIN
FILE

TOPICS DISCUSSED AND ACTION TAKEN

- USED MOLAR U:F RATIOS, AS SUPPLIED BY MANUFACTURERS OF RESINS, TO CALCULATE EXCESS F FOR EACH MILL, EXCEPT MILL D. (NO DATA GIVEN)

- TRIED TO COME UP WITH A TEST FOR FREE HCHO, BUT DID NOT HAVE ENOUGH CONFIDENCE IN SULFITE TITRATION DUE TO THE FACT THAT, WHEN USED ON SET-UP RESIN DUST, THE SULFITE TENDED TO BREAK THE DUST DOWN INTO U AND F, GIVING HIGH F READINGS UPON TITRATION.

Signature

RADIAN CORPORATION

TELEPHONE CALL RECORD

☐ Incoming Call
☐ Outgoing Call

Project No.	
Project Name	VA. FORMALDEHYDE
Date	7-22-87
Time	9:40 AM
Person Calling	TED WHITE
Activity	
Person Called	LARRY NEWTON
Activity	RESIN CHEMIST - GA. PACIFIC CO. (RESIN SUPPLIER)
General Subject	(404) 981-3220 ATLANTA

Distribution: C. BURKLIN FILE

TOPICS DISCUSSED AND ACTION TAKEN

- TWO TESTS ARE GENERALLY USED TO DETERMINE THE MOLE RATIOS OF U:F IN A RESIN
  - KELJHAL N
  - ~~PERKIN TEST~~ PHOSPHORIC ACID (DISTILLATION)

- SULFITE TITRATION TEST BREAKS DOWN SOME OF THE POLYMER. HIS FEELING - SHOULD BE CHILLED.

- THERE IS SOME EVIDENCE THAT "FREE" HCHO DOES NOT AFFECT EMISSION THAT COMES OFF THE PRESS*: PRESS CONDITIONS HAVE MORE OF AN EFFECT.

- I ASKED LARRY IF HE FELT THAT THERE WAS A BASIS FOR COMPARISON BETWEEN THE SULFITE TITRATION "FREE" HCHO & THAT DETERMINED BY MOLAR RATIO. HE FELT THAT THERE PROBABLY WAS NOT A GOOD BASIS FOR THIS.

Signature Ted A. White

* ESPECIALLY NOW THAT "LOW-EMITTING" RESINS ARE PREDOMINANT.